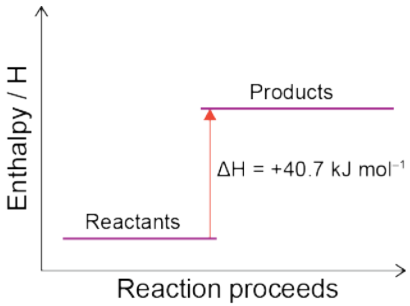
Assessment Schedule – 2017

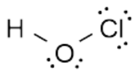
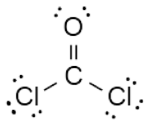
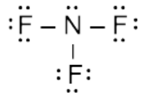
Chemistry: Demonstrate understanding of bonding, structure, properties and energy changes (91164)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Exothermic The temperature increased / energy or heat has been released into the surroundings / energy is lost from the substance ($CaCl_2$)	• Correct term with reason.		
(b)(i)	The water in sweat is changing state from liquid to gas. It needs to absorb energy to break the forces / bonds between liquid water molecules. It absorbs this from the heat of the body. The temperature of the body increases when exercising, so more water can be evaporated.	• Identifies absorption of energy (or used) OR bonds breaking.	• Identifies the state change as **bond breaking** and EITHER link this to (heat) energy used / endothermic OR links to increased / faster evaporation due to increased heat from exercise.	• Full explanation including linking: state change to bond breaking with energy used / endothermic, and in turn to increased / faster evaporation due to increased heat from exercise AND correct enthalpy diagram with labels.
(ii)	 *Can show activation energy but not required.*	• Diagram correctly drawn, but not labelled.	• Diagram correctly drawn and fully labelled.	
(iii)	Sodium chloride is an ionic substance made up of Na^+ and Cl^- ions arranged in a (3D) lattice and held together by ionic bonds. The δ- O of polar water molecules are attracted to the positive Na^+, while water's δ+ H is attracted to the negative Cl^-, this attraction is sufficiently strong to overcome the attractions between the ions in the salt / crystal /lattice (and between the water molecules in the solvent), dissolving the NaCl. See **Appendix One** for an example of labelled diagram.	• Identifies that NaCl is ionic made up of Na^+ and Cl^- ions. • Identifies H_2O is polar / δ– O and δ+ H.	• Explains the attractions between polar water molecules and the two types of ion.	• Solubility of NaCl fully explained supported by a diagram(s) showing the correct arrangement of water and Na^+ and Cl^-, in terms of attractions.

(c)	$n(Fe_2O_3) = \frac{50.0\text{ g}}{160\text{ g mol}^{-1}} = 0.313\text{ mol}$ $n(CuO) = \frac{50.0\text{ g}}{79.6\text{ g mol}^{-1}} = 0.628\text{ mol}$ **Reaction 1:** If 1 mole of Fe_2O_3 releases 852 kJ energy 0.313 mol × 852 kJ mol^{-1} = 266 kJ energy released **Reaction 2:** If 3 mole of CuO releases 1520 kJ energy Then 1 mole of CuO releases 507 kJ energy 0.628 mol × 507 kJ mol^{-1} = 318 kJ energy released So 50.0 g CuO releases more energy than 50.0 g Fe_2O_3 OR CuO releases more energy (52 kJ) than Fe_2O_3 OR **Reaction 2** releases more energy.	• Amount (moles) of both Fe_2O_3 and CuO correct.	• Correctly calculates energy released for either Reaction 1 or Reaction 2.	• Both Fe_2O_3 and CuO calculations with units (kJ) are correct with appropriate significant figures, and a statement identifying CuO / Reaction 2 as releasing more energy.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e	3e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i)	 bent / v-shaped  trigonal planar  trigonal pyramid	• Two Lewis structures (electron dot diagrams) correct AND Two shapes correct.		
(ii)	Bond angle is determined by the number of electron density regions around the central atom, which are arranged into a position to minimise repulsion / are arranged as far apart from each other as possible (maximum separation). HOCl has 4 electron density regions / areas of negative charge around the central O atom. This means the electron density regions around the central atom is arranged with maximum separation in a tetrahedral shape with a bond angle of 109.5°**,** to minimise (electron-electron) repulsion. Due to the presence of two non-bonding pairs of electrons / regions (or two bonding regions) on the central O atom, HOCl has an actual shape that is bent / v-shaped / angular. $COCl_2$ has only 3 electron density regions / areas of negative charge around its central C atom so the electron density regions around the central atom is arranged with maximum separation in a trigonal planar shape with a bond angle of 120°, to minimise (electron-electron) repulsion. Since $COCl_2$ has only bonding electron pairs (no non-bonding pairs) on its central atom, the actual shape is trigonal planar (with bond angles of 120°).	• Identifies the numbers of electron density regions / electron clouds / regions of negative charge around the central atoms for ONE molecule. OR Identifies non-bonding pairs and bonding pairs of electrons on the central atoms for ONE molecule.	• Links areas of negative charge around the central atom to **minimise** repulsion (maximum separation) and bond angle OR shape for ONE molecule.	• Justifies the correct bond angle and shapes of BOTH molecules by linking electron density regions around the central atom to bond angles and shape.
(b)(i) (ii)	Dichloromethane is polar. Tetrachloromethane is non-polar. In CCl_4, the four C–Cl bonds are polar, i.e. have a dipole, due to the difference in electronegativity between C and Cl. These (equally sized) dipoles are arranged in a symmetric **tetrahedral** shape, resulting in the dipoles / bond polarities cancelling each other out, so CCl_4 is non-polar. In CH_2Cl_2, there are two types of bond, C–H and C–Cl, each polar with dipoles due to the difference in electronegativity between C and H and C and Cl. These dipoles have different polarities / sizes as H and Cl have different electronegativities. (Despite the symmetric tetrahedral arrangement) the different (sized) dipoles / bond polarities do not cancel each other out, so CH_2Cl_2 is polar.	• Identifies polarity of both molecules. • Identifies that the atoms **within the bond**s have different electronegativities. (For one type of bond)	• Links bond polarity / or bond dipoles / atoms δ- and δ+ to electronegativity differences between **bonded** atoms for one molecule. **OR** Uses symmetry / differing dipoles to link molecule polarity to dipoles cancelling / not cancelling for one molecule.	• Justifies polarity of dichloromethane and non-polarity of tetrachloromethane by referring to differences in electronegativity, dipoles, and symmetry of molecules.

(c)	**Reaction 1** **Hydrazine and oxygen** Bond breaking: N–N 158; N–H × 4 1564; O=O 498; total 2220 Bond making: N≡N 945; O–H × 4 1852; total 2797 Bond breaking – bond making 2220 – 2797 = –577 kJ mol^{-1} **Reaction 2** **Hydrazine and Fluorine** N–N 158; N–H × 4 1564; F–F × 2 318; total 2040 N≡N 945; H–F × 4 2268; total 3213 Bond breaking – bond making 2040 – 3213 = –1173 kJ mol^{-1} (or -1170 kJ mol^{-1}) **Reaction 2** releases more energy than **Reaction 1** (by 596 kJ mol^{-1}).	• Identifies the bonds broken and bonds formed for both equations. OR Correct process for one reaction.	• Correct process giving the correct answer for one reaction.	• Correct process and answers for both reactions, including correct units (kJ mol^{-1}), and states **Reaction 2** releases more energy.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e	3e

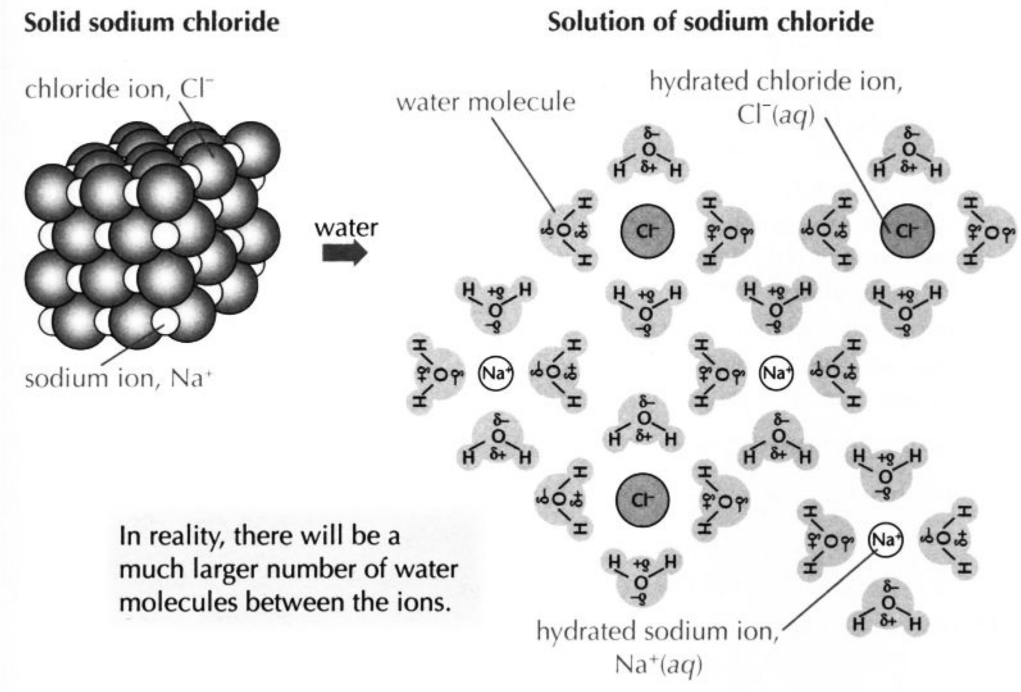
<table>
<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>THREE
(a)</td><td>
<table>
<tr><th>Solid</th><th>Type of solid</th><th>Type of particle</th><th>Attractive forces between particles</th></tr>
<tr><td>Al(s)
(Aluminium)</td><td>metal / metallic</td><td>atoms
(or cations and delocalised valence electrons)</td><td>metallic (bonds)</td></tr>
<tr><td>$MgCl_2(s)$
(Magnesium chloride)</td><td>ionic compound</td><td>ions</td><td>ionic (bonds)</td></tr>
<tr><td>$S_8(s)$
(Sulfur)</td><td>molecular</td><td>molecules</td><td>intermolecular (bonds)</td></tr>
</table>
</td><td>TWO rows or TWO columns correct.</td><td>Correct table.</td><td></td></tr>
<tr><td>(b)</td><td>Sulfur has the lowest melting point.
Sulfur is a molecular substance with weak intermolecular forces between the molecules. These forces do not require much energy to overcome, so they will break at lower temperatures, giving sulfur a lower melting point.
Al is a metal with strong metallic bonds. These attractions require a lot of energy to overcome, so the melting point is higher than sulfur's melting point.
$MgCl_2$ is an ionic compound with strong ionic bonds between the cations and anions. These bonds also require a lot of energy to overcome, so the melting point is also higher than sulfur's melting point.
(Candidates are not expected to know whether Al or $MgCl_2$ has the higher melting point.)</td><td>Describes the attractive intermolecular forces as weak or requires a small amount of heat / energy to break for S_8.
Describes the attractive intermolecular forces as strong or requires a large amount of heat / energy to break for $MgCl_2$.
Describes the attractive intermolecular forces as strong or requires a large amount of heat / energy to break for Al.</td><td>Links the correct attractive forces / bonding strength to energy / heat requirements for TWO of the substances.</td><td>Justifies choice by linking the correct attractive forces / bonding strength for ALL three substances to energy requirements and in turn to melting point.</td></tr>
<tr><td>(c)</td><td>Aluminium is malleable.
Aluminium is a metal made up of atoms / cations in a sea of electrons which are held together by non-directional metallic bonds in a (3D) lattice. The metallic bonds are non-directional as the (bonding) electrons are delocalised across the lattice / shared by many atoms. When a force (or pressure) is applied the atoms / layers can move without breaking / disrupting these non-directional bonds thus the structure can change shape without breaking the lattice.</td><td>Identifies aluminium and describes bonding as non-directional.
OR
Describes structure of aluminium (could be shown in a diagram) as a lattice.</td><td>Links malleability of aluminium to non-directional metallic bonding.
OR
Links malleability of aluminium to layers / atoms able to move past each other with pressure / force or without breaking bonds.</td><td>Justifies choice with respect to structure and non-directional bonding for aluminium.</td></tr>
</table>

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	1e	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24

Appendix One: Question One (b)(iii).



Suzanne Boniface, *ESA Study Guide Level 2 Chemistry* (Auckland: ESA Publications (NZ) Ltd, 2012), p. 115.